(A) WITHOUT PROXIES

(A) WITH SERVER AND PLAYER PROXIES

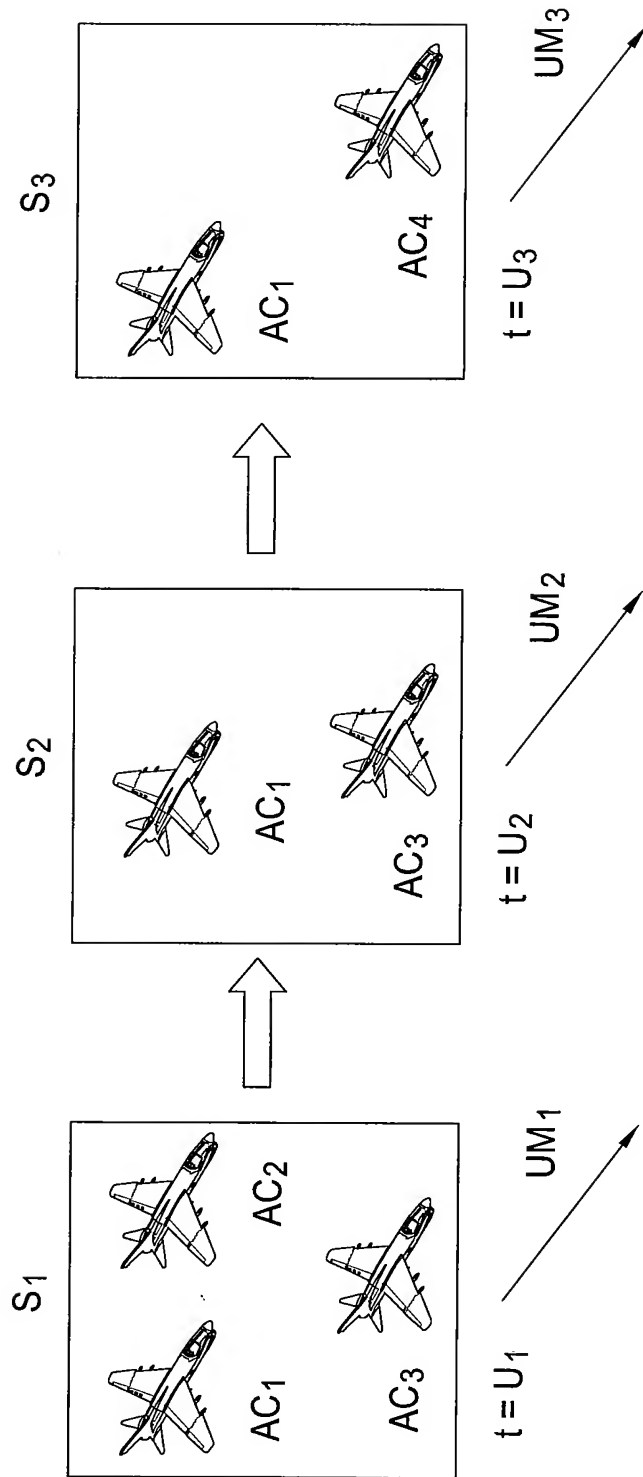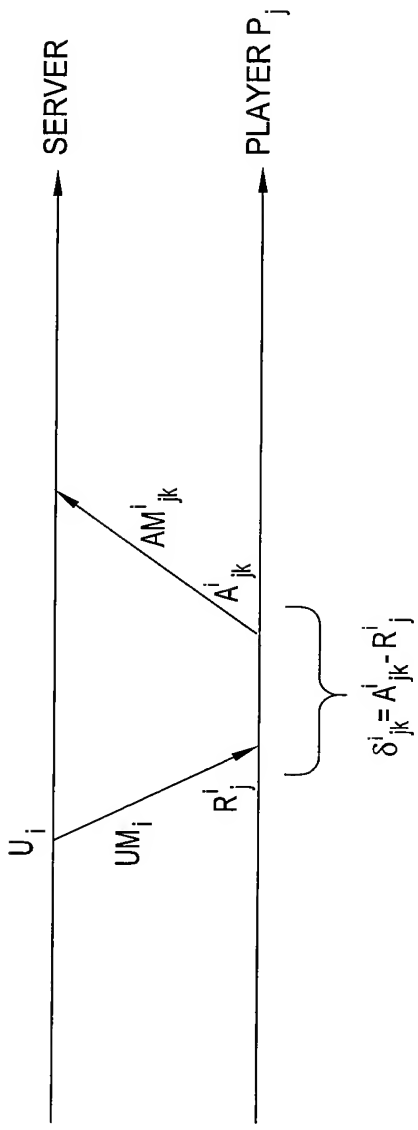DISTRIBUTED GAME ENVIRONMENT

FIG. 1

FIG. 2

MESSAGE EXCHANGE BETWEEN SERVER AND PLAYERS
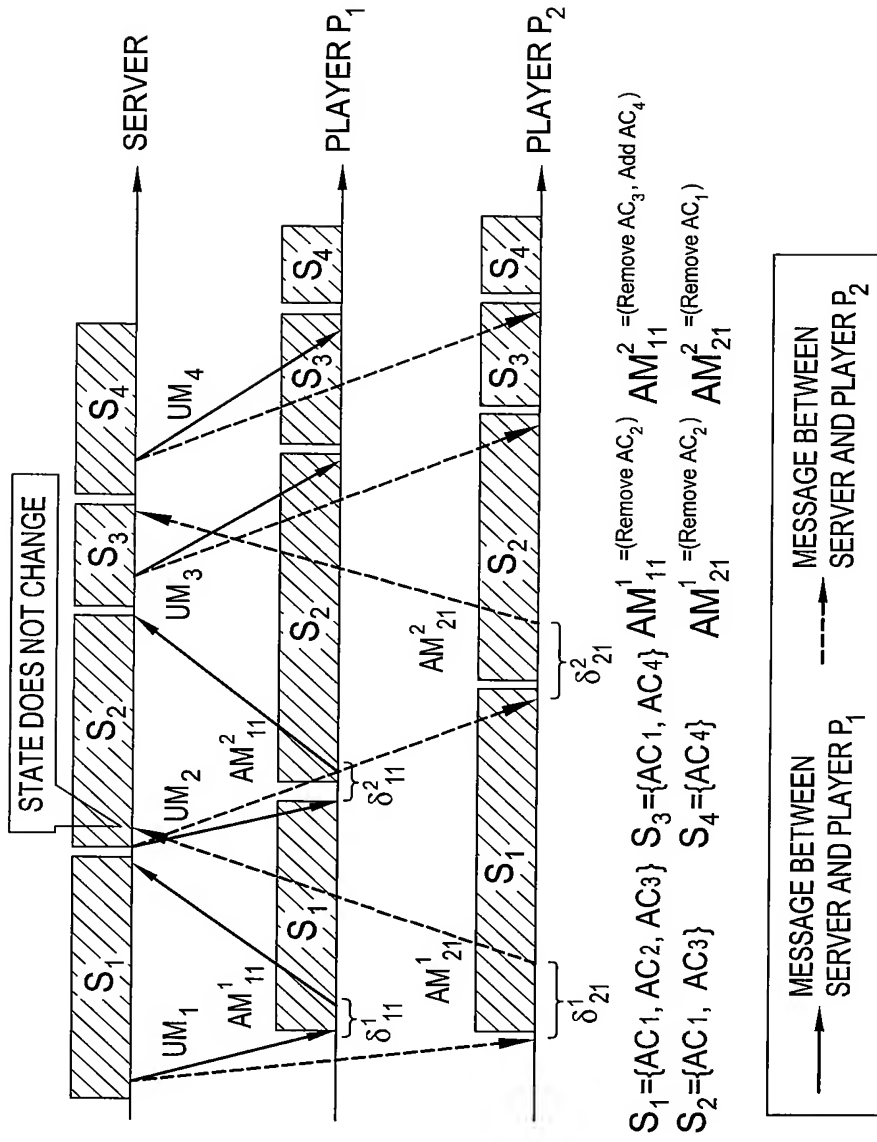
FIG. 3

Figure 3 shows: SERVER, PLAYER P_j, with U_i, UM_i, R_j^i, AM_{jk}^i, A_{jk}^i, and $\delta_{jk}^i = A_{jk}^i - R_j^i$

ALGORITHM FAIR-ORDER MESSAGE QUEUEING (ACTION_MESSAGE M_k):
1: COMPUTE $D(M_k)$ = DELIVERY TIME OF M_k;
2: INSERT M_k INTO DELIVERY QUEUE SORTED ACCORDING TO $D(M_k)$;
3: IF (DELIVERY QUEUE SIZE > 1)
4:     RECOMPUTE DELIVERY TIME OF EXISTING MESSAGES;
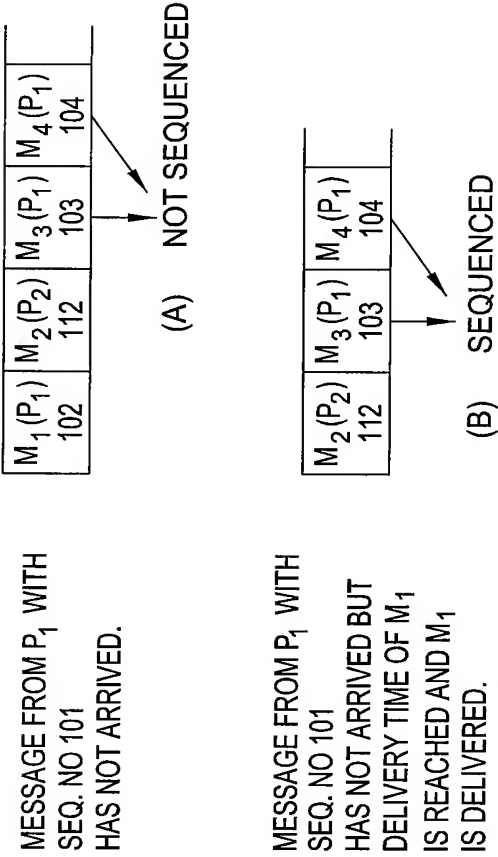
ALGORITHM FOR FAIR-ORDER MESSAGE QUEUEING

FIG. 5

$S_1 = \{AC_1, AC_2, AC_3\}$ $S_3 = \{AC_1, AC_4\}$ $AM^1_{11} =$(Remove AC_2) $AM^2_{11} =$(Remove AC_3, Add AC_4)
$S_2 = \{AC_1, AC_3\}$ $S_4 = \{AC_4\}$ $AM^1_{21} =$(Remove AC_2) $AM^2_{21} =$(Remove AC_1)

MESSAGE BETWEEN
SERVER AND PLAYER P_1

MESSAGE BETWEEN
SERVER AND PLAYER P_2

FAIR-ORDER MESSAGE DELIVERY FOR
STATE TRANSITIONS SHOWN IN FIG. 2

FIG. 4

MESSAGE FROM P_1 WITH
SEQ. NO 101
HAS NOT ARRIVED.

| $M_1(P_1)$ 102 | $M_2(P_2)$ 112 | $M_3(P_1)$ 103 | $M_4(P_1)$ 104 |

(A)   NOT SEQUENCED

MESSAGE FROM P_1 WITH
SEQ. NO 101
HAS NOT ARRIVED BUT
DELIVERY TIME OF M_1
IS REACHED AND M_1
IS DELIVERED.

| $M_2(P_2)$ 112 | $M_3(P_1)$ 103 | $M_4(P_1)$ 104 |

(B)   SEQUENCED

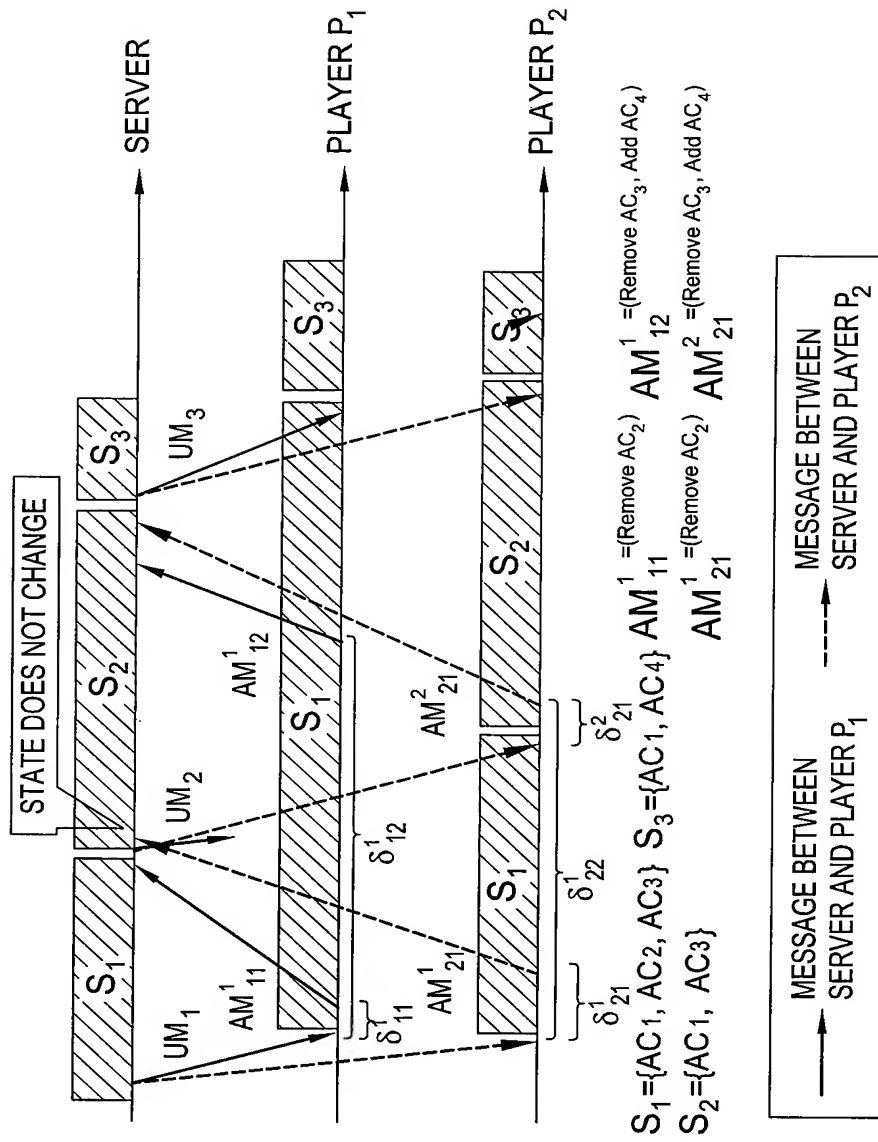EXAMPLE WHERE MESSAGES ARRIVE AFTER THEIR WAIT TIMEOUT.

FIG. 6

ALGORITHM FAIR-ORDER MESSAGE DEQUEUING (ACTION_MESSAGE M_k):
1: DELIVERY M_k AT $D(M_k)$;
2: IF (DELIVERY QUEUE SIZE > 1)
3:     RECOMPUTE DELIVERY TIME OF EXISTING MESSAGES;

FIG. 7

ADDITIONAL ALGORITHM FOR FAIR-ORDER MESSAGE DEQUEUING WHEN MESSAGES DO NOT ARRIVE WITHIN THEIR WAIT TIMEOUT.

$S_1 = \{AC_1, AC_2, AC_3\}$ $S_3 = \{AC_1, AC_4\}$ $AM^1_{11} = \text{(Remove } AC_2)$ $AM^1_{12} = \text{(Remove } AC_3, \text{ Add } AC_4)$

$S_2 = \{AC_1, AC_3\}$ $AM^1_{21} = \text{(Remove } AC_2)$ $AM^2_{21} = \text{(Remove } AC_3, \text{ Add } AC_4)$

MESSAGE BETWEEN
SERVER AND PLAYER P_1

MESSAGE BETWEEN
SERVER AND PLAYER P_2

EXAMPLE OF AN INCONSISTENT VIEW OF THE GAME
BETWEEN TWO PLAYERS, WHERE THE SEQUENCE OF STATE CHANGES
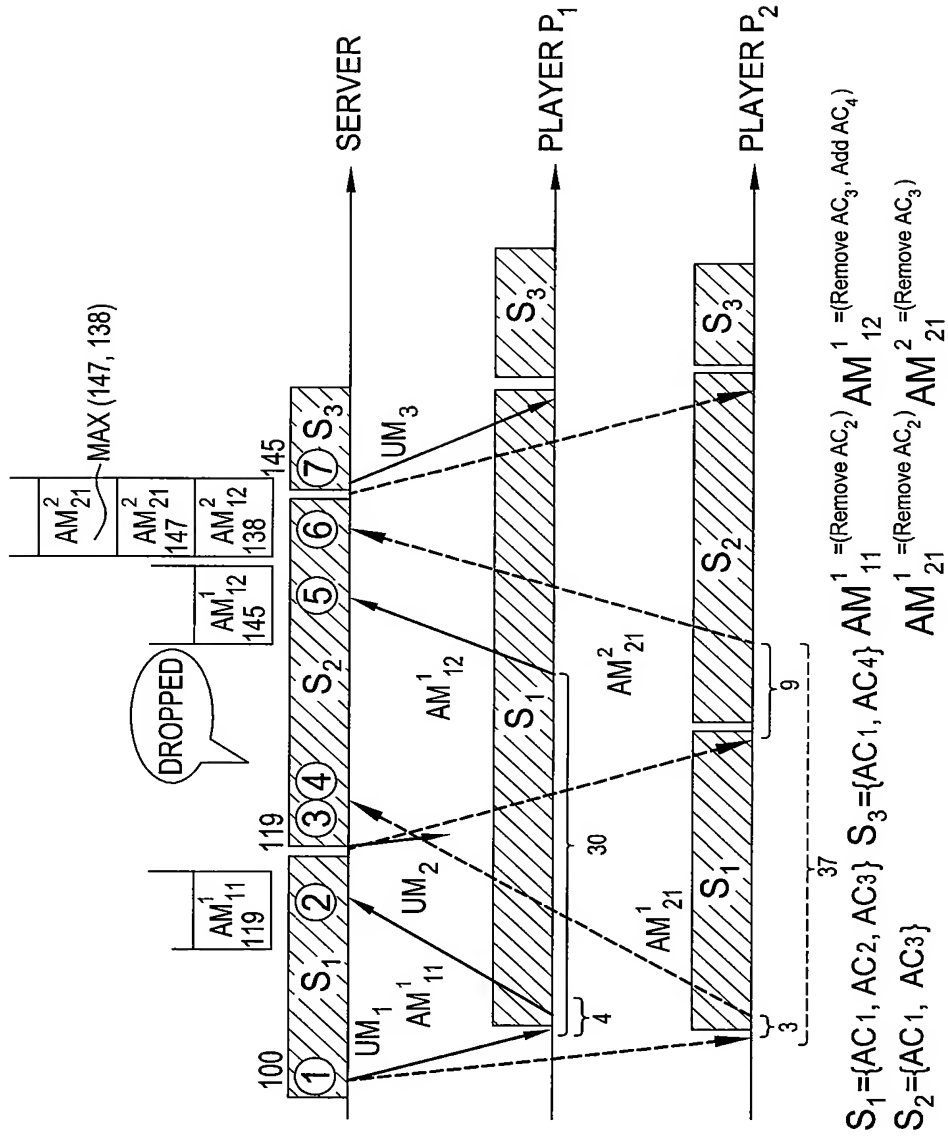AT THE SERVER IS SHOWN IN FIG. 2

FIG. 8

FIG. 9

EXAMPLE SHOWING THE FAIR-ORDER MESSAGE DELIVERY ALGORITHM.

FIG. 10

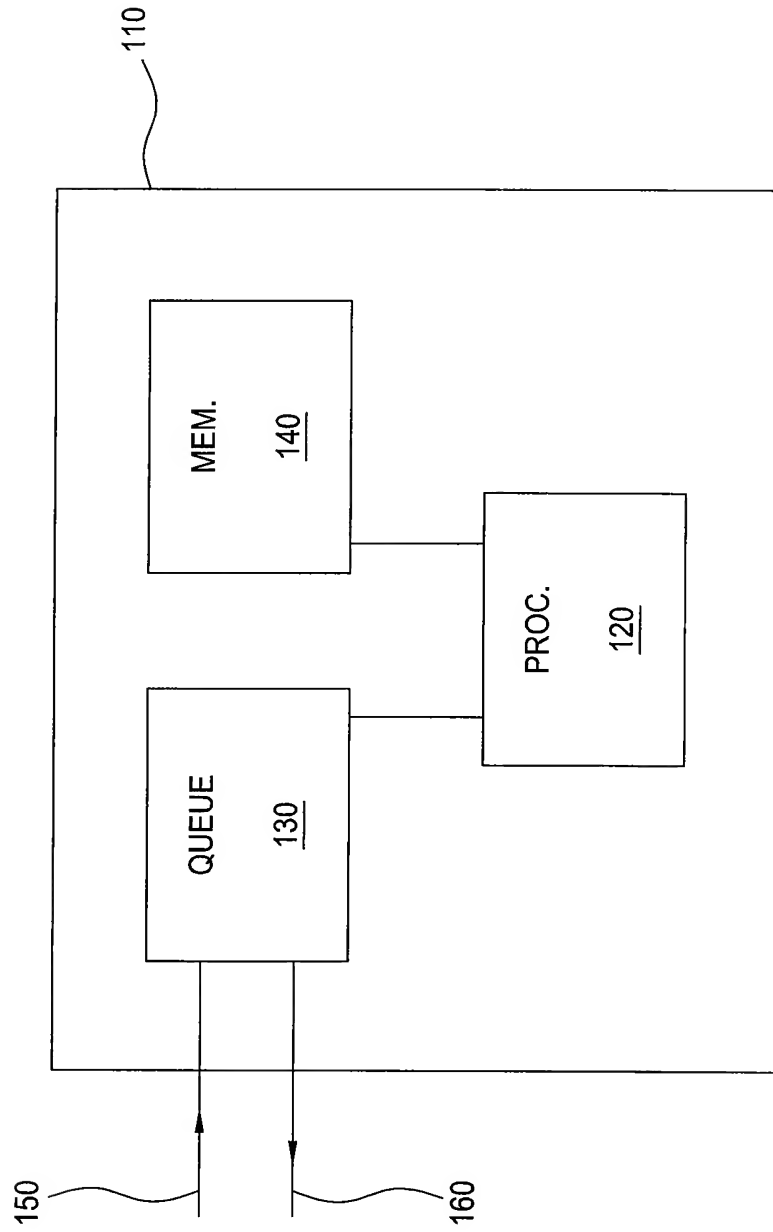EXAMPLE SHOWING THE FAIR-ORDER MESSAGE DELIVERY ALGORITHM WITH OUT-OF-ORDER MESSAGE RECEPTION.

FIG. 11